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Afforestation effects on SOC in former cropland in Denmark: oak and spruce chronosequences resampled after 12 years.

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Surplus of agricultural products and the increasing demand for environmental services has induced the conversion of cropland to plantation forests. Several environmental processes change as a result of such land-use change, e.g. water recharge, nitrate leaching, and soil properties, but also effects on carbon sequestration have attracted research efforts due to its role in climate change mitigation. In Denmark, monocultures of oak (Quercus robur L.) and Norway spruce (Picea abies (l.) Karst.) have been common in afforestations during the last decades. Chronosequences are commonly used to address SOC sequestration after land-use change, however, no previous study has combined and compared results of the chronosequence approach and repeated sampling. As a part of the GHG Europe project we conducted a combined chronosequence/resampling study in a former cropland area (Vestskoven) that has been successively afforested with both tree species over the past 40 years. This area is well suited for land-use change and tree species effect studies as it has homogeneous soil conditions and includes differently aged stands providing decadal time scales.

Previous carbon stock data from 1998 showed increasing carbon storage along the chronosequence in forest floors, while soil organic carbon stocks (0-25 cm) decreased, within a time span of 30 years. Our objective was to investigate whether resampling of the same chronosequences after 12 years would show evidence of a tree species-specific effect on soil carbon after afforestation, or if the tree species effect would still be constrained to forest floors. The chronosequence trajectory showing an increase in forest floor carbon stocks was validated by resampling after 12 years, however, carbon accumulation rates decreased for both tree species from 1998 to 2010, from 0.35 to 0.14 Mg C ha-1 yr-1 in spruce and from 0.08 to 0.01 Mg C ha-1 yr-1 in the oak chronosequence. In addition, current carbon sequestration rates in forest floors detected by resampling decreased with stand age.

SOC stocks based on chronosequence trends in 2010 were similar to those found in 1998, however, there was a shift toward less negative rates for both oak (-0.64 to -0.31 Mg C ha-1 yr-1) and spruce (-0.37 to 0 Mg C ha-1 yr-1). On an individual stand basis, current change rates (based on repeated sampling after 12 years) indicated a change from carbon loss in the youngest stands of both tree species to carbon accumulation in soils from older stands.

The results of this combined chronosequence and resampling study suggest that afforested soils on former cropland within the temperate region may induce carbon losses in the mineral soil during the first decades after planting followed by a recovery phase of yet unknown duration. Forest floor C sequestration peaked already during the first decades following conversion, thereby mitigating the temporary loss in mineral soil C stocks.

Keywords: land-use change, afforestation, carbon stocks, forest floor, mineral soil, oak, Norway spruce, chronosequence, repeated sampling.